

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
30 October 2003 (30.10.2003)

PCT

(10) International Publication Number
WO 03/089762 A1

(51) International Patent Classification⁷: **E21D 9/10, E21C 25/16, 27/12, 27/24**

(21) International Application Number: PCT/AU03/00473

(22) International Filing Date: 22 April 2003 (22.04.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PS 1868 22 April 2002 (22.04.2002) AU

(71) Applicant (for all designated States except US):
ODYSSEY TECHNOLOGY PTY LTD [AU/AU];
Room S217, Level 2, Hawken Engineering Building, Staff
House Road, University of QUEENSLAND, St. Lucia,
QLD 4072 (AU).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— of inventorship (Rule 4.17(iv)) for US only

Published:

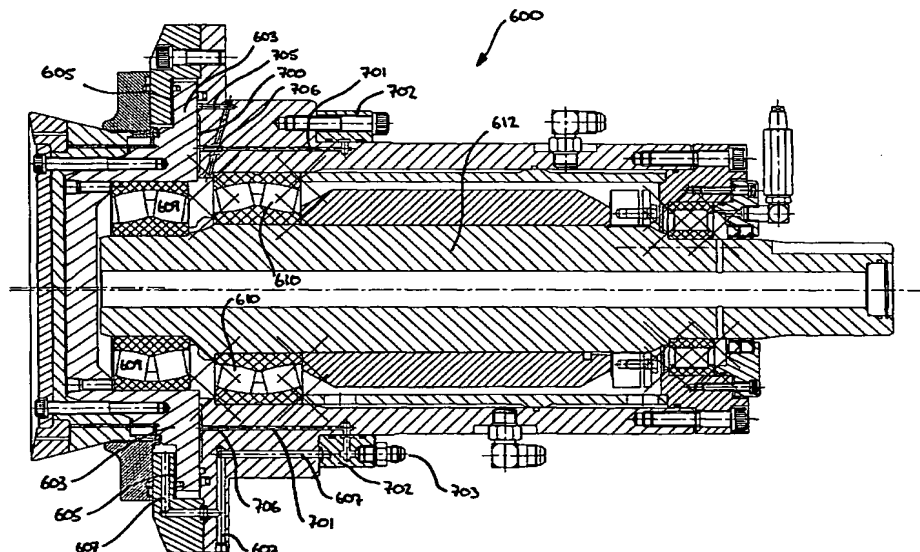
— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(72) Inventor; and
(75) Inventor/Applicant (for US only): **SUGDEN, David, Burnet [AU/AU];** 33 Kingston Heights, Kingston Beach, TAS 7050 (AU).

(74) Agent: **BALDWIN SHELSTON WATERS;** 60 Margaret Street, Sydney, NSW 2000 (AU).

(54) Title: OSCILLATING DISC CUTTER WITH SPEED CONTROLLING BEARINGS



(57) Abstract: An oscillating disc cutter (10) including a cutting disc (602) and a drive mechanism. The drive mechanism including a drive shaft (612) to effect eccentric oscillation of the cutting disc and a radial bearing (609) disposed to permit relative rotation between the drive shaft and the cutting disc. The cutter further including a hydrostatic axial bearing (700) disposed to react axial forces while accommodating induced rotation of the cutting disc when operatively engaged and to induce a rotational drag thereby limiting rotational speed of the cutting disc when free running. A water pressurised fluid bearing (605) induces a predetermined axial load in the hydrostatic bearing such that a predetermined maximum running clearance in the hydrostatic bearing is maintained.



WO 03/089762 A1

- 1 -

TITLE: OSCILLATING DISC CUTTER WITH SPEED CONTROLLING BEARINGS**FIELD OF THE INVENTION**

This invention relates to an oscillating disc cutter with speed controlling bearings
5 and has been devised particularly though not solely to prevent high speed rotation of a disc cutter when the cutting disc is disengaged from a rock face.

BACKGROUND OF THE INVENTION

Oscillating disc cutters of the type described in international patent specification PCT/AU00/00066 (the contents of which are incorporated herein by way of cross
10 reference) have the general requirement that a mechanism is provided to prevent the cutting disc from rotating at a high speed when the cutter is not engaging the rock face.

It should be noted that the reference to international patent specification PCT/AU00/00066 is not an admission that this publication forms part of the common general knowledge in Australia or in any other territory.

15 In normal cutting mode, when the disc cutter is presented to the cutting face the disc naturally rotates at about 30-40 rpm in the opposite direction to the shaft due to the rubbing friction caused by displacement difference between the diameter of the cutting disc and oscillating path diameter. It will be appreciated that this low speed rotation in the cutting mode is advantageous because it provides for even wear of the cutting disc
20 and prevents temperature build-up at one point on the cutter.

However, during free running mode, when the cutter is not in contact with the rock face, torque transmitted to the disc from the shaft through bearing 609 (shown in Figure 7 of PCT/AU00/00066), causes the disc cutter to rotate in the same direction as the shaft. Without some degree of control, the cutter would speed up to around the same speed as
25 the shaft, i.e. around 3000 rpm.

Reapplying the cutter to the rock face causes an almost instantaneous acceleration of the disc from around 3000 rpm in one direction to around 30-40 rpm in the opposite direction. This can cause significant wear and damage to the cutting edge. In international patent specification PCT/AU00/00066, a solution is proposed of using a
30 gear arrangement shown generally 616 in Figure 7 of that specification.

Such a gear arrangement is heavy, prone to wear, maintenance issues, and causes additional drag when the cutter is engaged with the rock face.

- 2 -

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

SUMMARY OF THE INVENTION

Accordingly the present invention provides an oscillating disc cutter including a cutting disc and a drive mechanism, the drive mechanism including a drive shaft to effect eccentric oscillation of the cutting disc and a radial bearing disposed to permit relative rotation between the drive shaft and the cutting disc, the cutter further including a first axial bearing disposed to react axial forces while accommodating induced rotation of the cutting disc when operatively engaged and to induce a rotational drag thereby limiting rotational speed of the cutting disc when free running.

Preferably, the cutter further includes a second bearing to induce a predetermined axial load in the first bearing.

Preferably, the second bearing substantially reacts the axial forces induced by the first bearing.

Preferably, the first bearing is a oil operated hydrostatic bearing and the second bearing is a fluid pressurised and lubricated bearing.

Preferably, pressure in the fluid bearing is maintained at a level such that a predetermined maximum running clearance in the hydrostatic bearing is maintained thereby inducing shear forces in the oil of the hydrostatic bearing. Preferably, the shear forces cause rotational drag in the bearing thereby limiting the rotational speed of the cutting disc in when free running.

Preferably, the fluid bearing is takes the form of a water-pressurised annulus.

Preferably, the limited rotational speed of the cutting disc is 0 to 100 rpm.

BRIEF DESCRIPTION OF THE DRAWINGS

Notwithstanding any other forms that may fall within its scope, one preferred form of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Fig 1 is a cross sectional elevation through an oscillating disc cutter incorporating the present invention;

Fig 2 is cross sectional view of a variation of the disc cutter shown in Figure 1; and

Fig 3A is a partial view of a hydrostatic bearing face in accordance with the invention; and

Fig 3B is cross sectional view of the bearing face shown in Figure 3A.

DETAILED DESCRIPTION OF THE INVENTION

The oscillating disc cutter shown in the accompanying drawing is generally similar in configuration to that shown in Figure 7 of international patent specification

- 5 PCT/AU00/00066, with like numbers referring to the components in that drawing as described in the description of the international patent specification.

Instead of the bearings 605 and 606 from PCT/AU00/00066 being water lubricated, only bearing 605 in the present invention is water lubricated. Bearing 606 is replaced by a hydrostatic bearing 700 supplied with high pressure oil through an annular
10 passageway 701 inside a demountable ring 702, to which oil is supplied under pressure via nipple 703. The bearing 700 contains pockets 800 in the normal manner of hydrostatic bearings.

As can clearly be seen in Figure 3A, these pockets may be in the form of a concentric grid pattern on the casing body opposing the disc 603, however, in alternative
15 embodiments they may take on any form as is known in the art of hydrostatic bearings. In this embodiment there are ten pockets 800 evenly disposed in a circular array around the bearing. Each pocket's extremity is defined by a peripheral groove 801. A further oil channel groove in the form of a cross 802 dissects each pocket into four lands 803. Referring to Figure 3B, these lands are at substantially the same height as the bearing
20 surface between the pockets. Many hydrostatic bearings do not include these lands and the pockets are merely depressions in the bearing surface. However, in this embodiment, the lands effectively function to reduce the clearance gap between the bearing surfaces over a greater area thereby increasing the shear in the oil and enhancing the viscous drag characteristics of the bearing.

25 Oil is feed into the centre of each cross through a respective flow control orifice 706. Each respective orifice regulates the oil in each of the pockets of the bearing as is common in hydrostatic bearings.

Referring to Figure 2, oil exiting the bearing is able to seep either directly into the body of the device between bearings 609 and 610 or into outer drain channel 705 at the
30 periphery of the bearing.

Providing a set minimum load on the hydrostatic bearing is fluid bearing 605. This fluid bearing maybe considered simply as a pressurised annulus, however, is

- 4 -

referred to throughout as a fluid lubricated bearing. The fluid bearing surfaces include an annular plate portion of the disc 603 and a corresponding portion of the cutter housing opposing the annular plate. These bearing surfaces are separated by an annular gap into which water is introduced at pressure through a series of passageways 607. A
5 hose and hose fittings (not shown) may be used to transport pressurised water from a pressure pump (not shown). In this embodiment the water is en-route to the cooling jets for the cutting edge of the cutter however, in other embodiments, separate cooling water and bearing water systems may be used. In still further embodiments, different fluids may be used for cooling and pressurising the fluid bearing.

10 The pressurised water provides a force on the plate thereby maintaining clearance between the bearing surfaces and providing an opposing force to the hydrostatic bearing. It will be appreciated that by regulating the pressure of the water, the magnitude of opposing force may also be regulated. Accordingly, by carefully controlling the water pressure in the fluid bearing and the oil pressure in the hydrostatic bearing, the clearance
15 between the faces of the hydrostatic bearing can be set.

It will also be appreciated that the fluid bearing allows for a minute amount of axial yaw if the cutter head is differentially loaded. Such differential loading is accommodated and resisted by the hydrostatic bearing.

The fluid bearing surfaces may be covered with an antifriction material, as a safety
20 measure should the bearing surfaces contact, for instance, as a result of failed water supply or during transport.

Typical values for the oil pressure supplied to the hydrostatic bearing and water pressure supplied to the fluid bearing are 14,000 kPa and 800 kPa respectively.

In operation, the cutter is powered by a 2-pole induction motor which, with a
25 power supply at 50 Hz, rotates the dive shaft 612 at a speed of around 3000 rpm. Of course, alternative power supplies and a range of cutting speeds may be used.

However, it will be appreciated that drag inherent in the fluid and hydrostatic bearings provides a balancing torque to counter the rotation of the disc. By carefully selecting an appropriate pressure level in the fluid bearing, the clearance between the
30 faces of the hydrostatic bearing are such that the rate of shear of the oil will rise with increasing speed of the disc. The friction developed due to the shear in the oil balances the rotation causing torque thereby limiting the free running speed of the disc to a desired value.

- 5 -

It will be appreciated that as well as rotation speed and clearance in the hydrostatic bearing, the frictional forces developed will also depend upon the design of the hydrostatic bearing surfaces and oil pockets and viscosity of the oil used. In turn, oil temperature will affect oil viscosity and therefore bearing performance. In this
5 embodiment, standard hydraulic fluid is used however, other appropriate oils may be used as a replacement. The relationship between the viscosity of the oil selected and temperature is critical when selecting the oil.

Accordingly, the pressure of water supplied to the water lubricated bearing, the oil type, and the oil viscosity, temperature and pressure in the hydrostatic bearing are all
10 carefully selected and controlled where appropriate to ensure correct function of the bearing and to avoid damage to the parts. In this regard the oil is passed through a heat exchanger of sufficient capacity to control the oil temperature.

An additional retardation force may be applied by drag inherent in the fluid bearing. Disengaging the cutter from the rock face reduces the axial load on the
15 hydrostatic bearing which in turn causes the disc 603 to be forced closer to the water lubricated bearing surface 605. This may provide for an increase in drag thereby preventing the disc 603, to which the disc cutter 602 is bolted, from rotating at a high speed when the cutter is not engaging the rock face.

In this embodiment, the free running speed is selected to be about 30-40 rpm.
20 While this is in the reverse direction to the operational speed, the difference is small enough to prevent damage and substantial wear to the cutter disc. However, in alternative embodiments, the parameters of the system may be selected to provide for virtually any free running speed desired in the direction of the shaft.

Accordingly, the drag in each axial bearing combines to eliminate the need for the
25 gear arrangement 616 referred to in the description of Fig. 7 in international patent specification PCT/AU00/00066.

In alternative embodiments of the invention, other types of axial load bearings known in the art may replace the hydrostatic and fluid lubricated bearings. For instance, the hydrostatic bearing may be replaced by a Michell bearing and the fluid lubricated
30 bearing may take to form of a mechanical, hydrodynamic, electromagnetic or other type of bearing able to withstand and/or provide an axial load. In such embodiments, one or other of the bearings may have a more significant effect in controlling the speed of the cutter disc when free spinning.

- 6 -

Although the cutting device is of the type generally described in PCT/AU00/00030, it will be appreciated that various types of similar cutting devices may be used, with or without the nutating feature described in that patent specification.

It will be appreciated that the invention provides an effective means for limiting
5 the speed of the cutter disc when in free running mode without the use of mechanical parts which are comparatively higher wearing.

Thus, in essence, the water lubricated bearing 605 and the hydrostatic bearing function as drag brakes on the rotation of the disc 603 and hence of the cutter 602.

Although the invention has been described with reference to specific examples it
10 will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

CLAIMS

1. An oscillating disc cutter including a cutting disc and a drive mechanism, the drive mechanism including a drive shaft to effect eccentric oscillation of the cutting disc and a radial bearing disposed to permit relative rotation between the drive shaft and the cutting disc, the cutter further including a first axial bearing disposed to react axial forces while
5 accommodating induced rotation of the cutting disc when operatively engaged and to induce a rotational drag thereby limiting rotational speed of the cutting disc when free running.
2. An oscillating disc cutter according to claim 1 further including a second bearing
10 to induce a predetermined axial load in the first bearing.
3. An oscillating disc cutter according to claim 2 wherein the second bearing substantially reacts the axial forces induced by the first bearing.
4. An oscillating disc cutter according to claim 2 or 3 wherein the first bearing is of relatively high friction, and the second bearing is of relatively lower friction.
- 15 5. An oscillating disc cutter according to any one of the claims 2 to 4 wherein the first bearing is a hydrostatic bearing.
6. An oscillating disc cutter according to any one of claims 2 to 5 wherein the second bearing is a fluid lubricated bearing.
7. An oscillating disc cutter according to claim 5 or 6 wherein the hydrostatic bearing
20 substantially reacts the axial cutting forces in the operative cutting mode.
8. An oscillating disc cutter according to claim 7 wherein the hydrostatic bearing is oil operated.
9. An oscillating disc cutter according to claim 8 wherein the fluid bearing is pressurised.
- 25 10. An oscillating disc cutter according to claim 9 wherein pressure in the fluid bearing is maintained at a level such that a predetermined maximum running clearance in the hydrostatic bearing is maintained thereby inducing shear forces in the oil of the hydrostatic bearing.
11. An oscillating disc cutter according to claim 10 wherein the shear forces cause
30 rotational drag in the bearing thereby limiting the rotational speed of the cutting disc in when free running.

- 8 -

12. An oscillating disc cutter according to any one of claims 9 to 11 wherein the fluid bearing is pressurised with water.
13. An oscillating disc cutter according to claim 12 wherein the fluid bearing is takes the form of a water-pressurised annulus.
- 5 14. An oscillating disc cutter according to anyone of the preceding claims wherein the limited rotational speed of the cutting disc is 0 to 1500 rpm.
15. An oscillating disc cutter according to anyone of the preceding claims wherein the limited rotational speed of the cutting disc is 0 to 750 rpm.
16. An oscillating disc cutter according to anyone of the preceding claims wherein the
10 limited rotational speed of the cutting disc is 0 to 100 rpm.

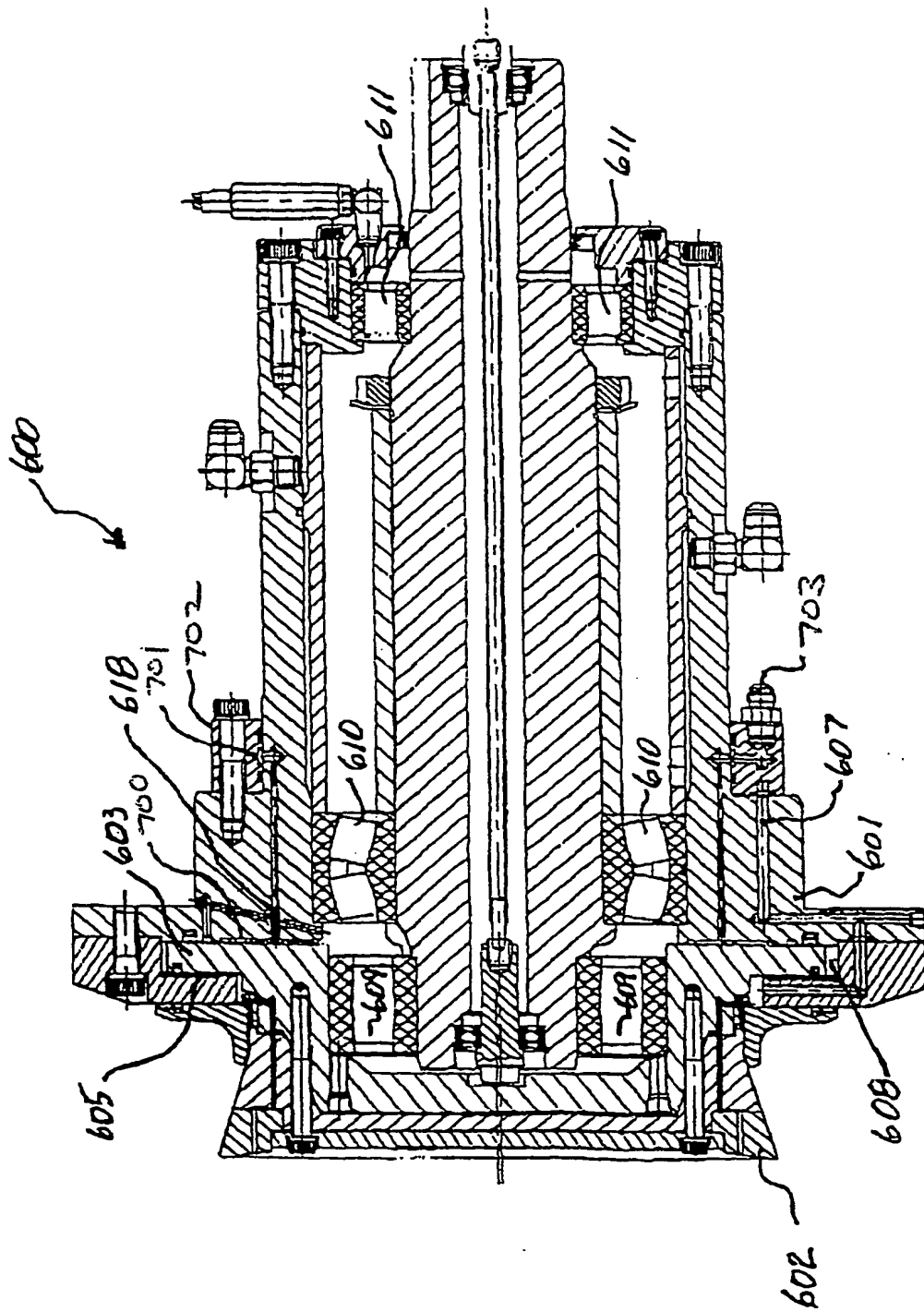


FIG. 1.

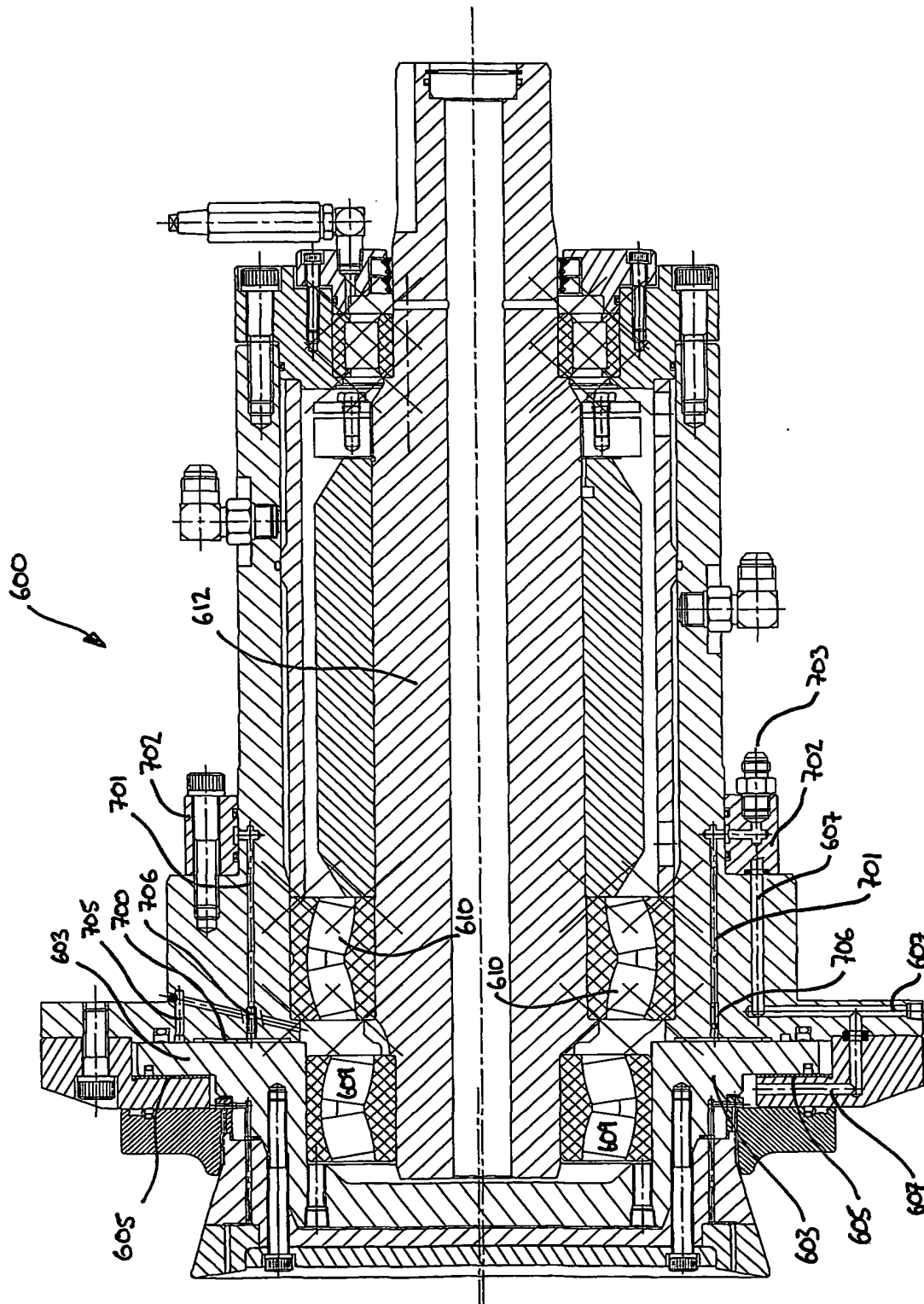
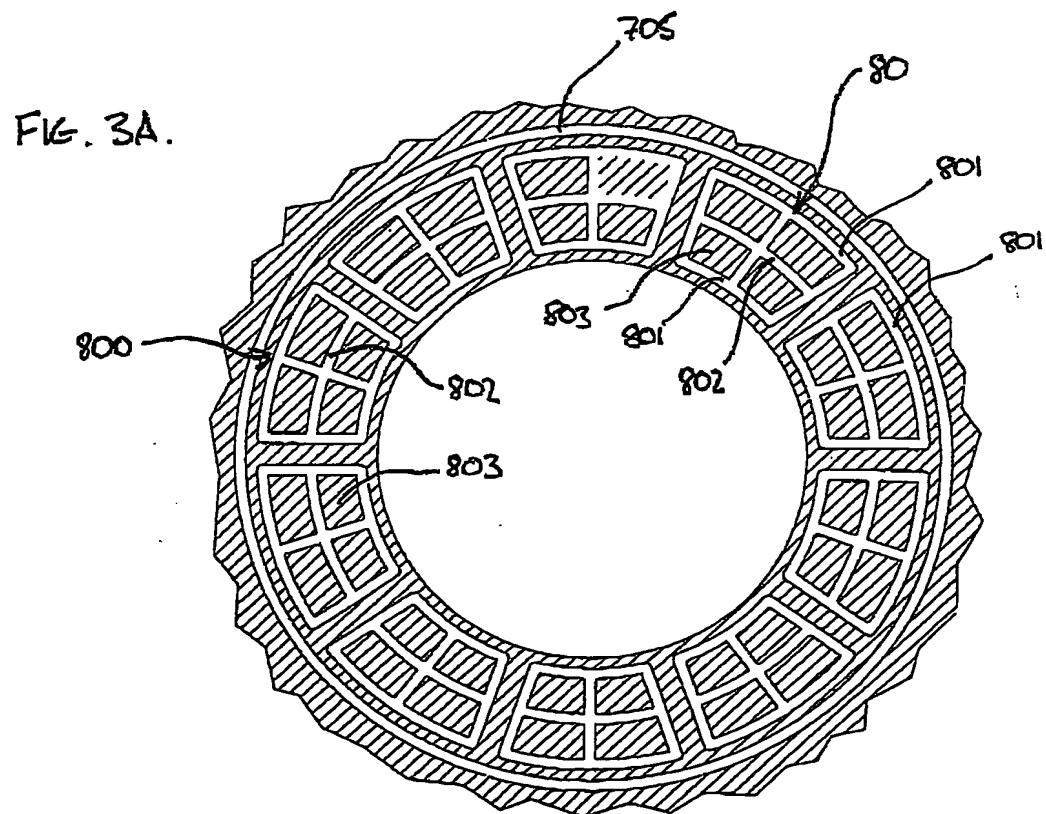
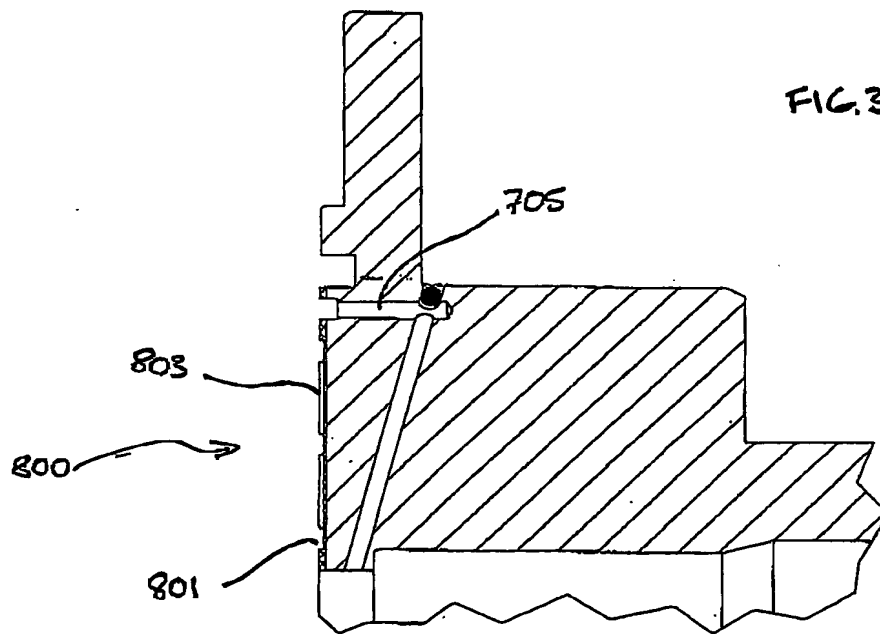


FIG. 2.



INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00473

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 7: **E21D 9/10, E21C 25/16, 27/12, 27/24**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

AU: **E21D 9/10, E21C 25/16, 27/12, 27/24, F16C 32/16**

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Dwpi: (E21D 9/10, E21C 25/16, 27/12, 27/24 and bear+) or (F16C 32/06 and hydrostatic+ and (disc or cut+))

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5125719 A (SNYDER) 30 June 1992 Column 4, line 46-column 8, line 8 and the claims	1-16
Y	WO 00/46486 A1 (ODYSSEY TECHNOLOGY PTY LTD) 10 August 2000 Figure 7	1-16
Y	EP 727562 A1 (ROLLS-ROYCE POWER ENGINEERING PLC) 21 August 1996 The whole document	1-16
Y	US 5462364 A (CHANDRASEKARAN et al) 31 October 1995 The whole document	1-16

☐

Further documents are listed in the continuation of Box C

☒

See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
3 June 2003

Date of mailing of the international search report

11 JUN 2003

Name and mailing address of the ISA/AU
AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pct@ipaaustralia.gov.au
Facsimile No. (02) 6285 3929

Authorized officer

LEOPOLD FILIPOVIC
Telephone No : (02) 6283 2105

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU03/00473

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
US	5125719	AU	17723/92	WO	9217684		
WO	200046486	AU	200027832	CA	2361657	EP	1157190
		US	2002093239				
EP	727562	CA	2169330	JP	8246777	US	5934761
US	5462364	CA	2120467	EP	618377		
END OF ANNEX							